Presentation To

RMRA Feasibility Study Steering Committee

Feasibility Study Update

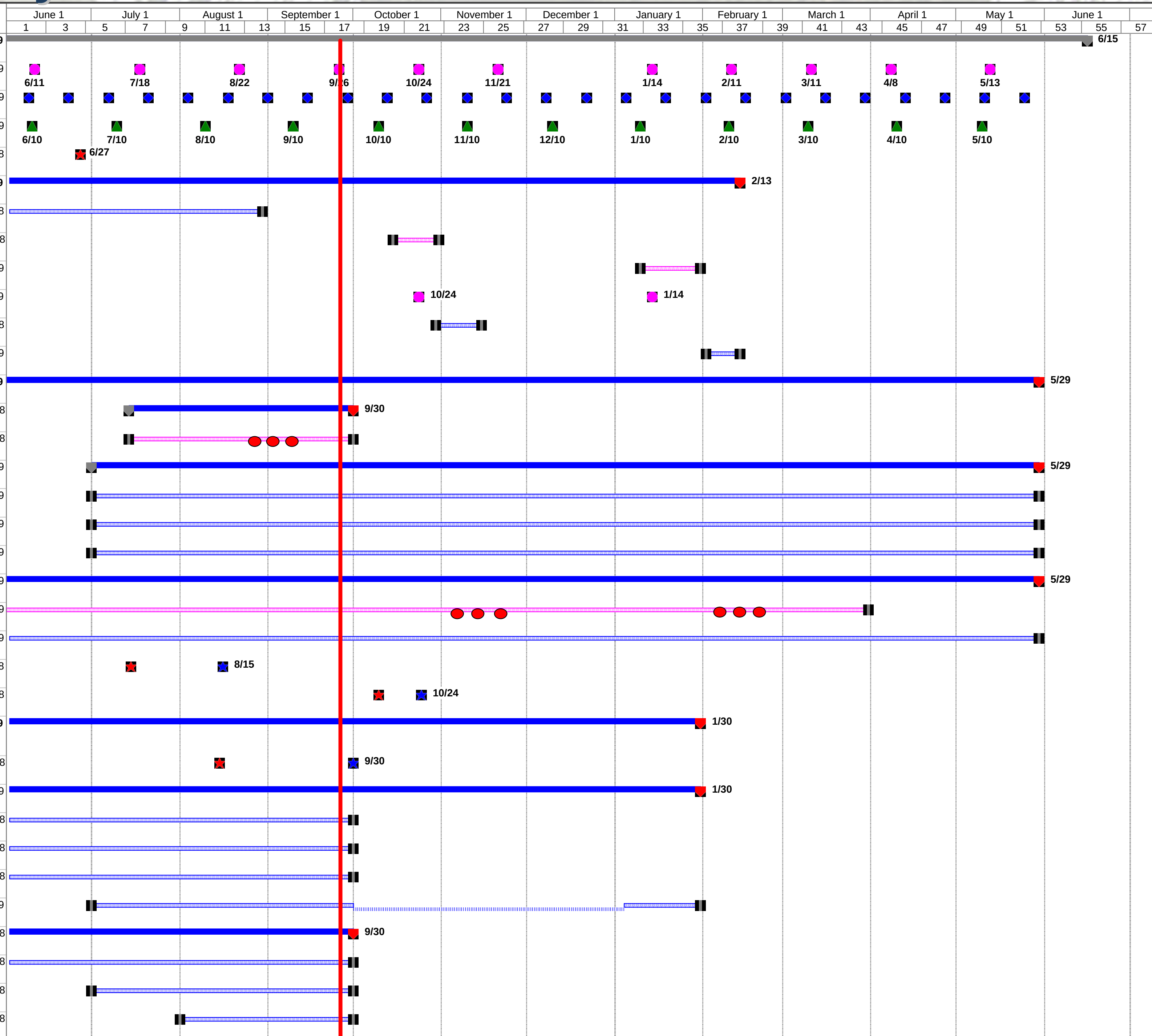
September 26, 2008

High Speed Rail Feasibility Study

TEMS, Inc. / Quandel Consultants, LLC

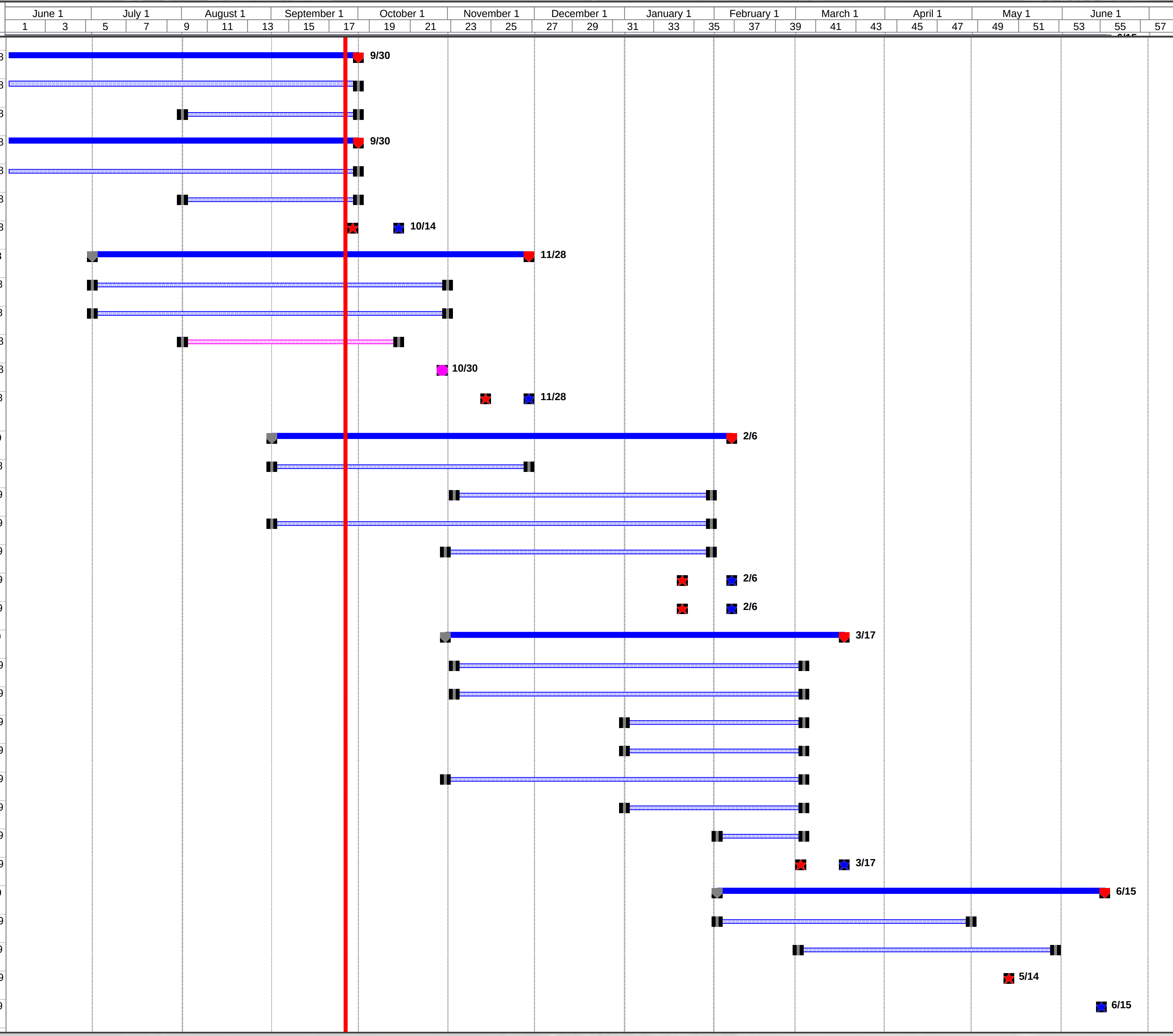
Study Work Schedule: Tasks 1 thru 4.3.3

ID	Task #	Task Name	Start	Finish
0	**1**	**Project Management**	**Sun 6/1/08**	**Mon 6/15/09**
1	1.1	Steering Committee Meetings	Wed 6/11/08	Wed 5/13/09
14	1.2	PMC Coordination Meetings	Mon 6/9/08	Mon 5/25/09
67	1.3	Monthly Progress Report to PMC	Tue 6/10/08	Sun 5/10/09
80	1.4	Project Management Plan	Fri 6/27/08	Fri 6/27/08
81	**2**	**Peer Review Panel**	**Mon 6/2/08**	**Fri 2/13/09**
82	2.1	Develop Panels	Mon 6/2/08	Fri 8/29/08
83	2.2	First Meetings (3) - Data Methodology	Wed 10/15/08	Thu 10/30/08
84	2.3	Second Meetings (3) - Alternatives Analysis	Sat 1/10/09	Fri 1/30/09
85	2.4	Powerpoint Presentation	Fri 10/24/08	Wed 1/14/09
88	2.5	Response to Panel (1)	Thu 10/30/08	Fri 11/14/08
89	2.6	Response to Panel (2)	Mon 2/2/09	Fri 2/13/09
90	**3**	**Scoping/Public Outreach**	**Sun 6/1/08**	**Fri 5/29/09**
91	3.1	Scoping	Mon 7/14/08	Tue 9/30/08
92	3.1.1	Scoping Workshops (3)	Mon 7/14/08	Tue 9/30/08
93	3.2	Ongoing Public Input	Tue 7/1/08	Fri 5/29/09
94	3.2.1	Media Relations	Tue 7/1/08	Fri 5/29/09
95	3.2.2	Monthly Updates	Tue 7/1/08	Fri 5/29/09
96	3.2.3	Stakeholder Database	Tue 7/1/08	Fri 5/29/09
97	3.3	Policy Outreach	Sun 6/1/08	Fri 5/29/09
98	3.3.1	Policy Outreach Workshops (6)	Sun 6/1/08	Mon 3/30/09
99	3.3.2	Policy Outreach Coordination	Mon 6/2/08	Fri 5/29/09
100	3.4	Stakeholder Outreach Approach Report	Tue 7/15/08	Fri 8/15/08
101	3.5	Scoping Technical Report	Fri 10/10/08	Fri 10/24/08
102	**4**	**Methodology, Data Collection and Summary of Existing Conditions**	**Mon 6/2/08**	**Fri 1/30/09**
103	4.1	Methodology Report	Fri 8/15/08	Tue 9/30/08
104	4.2	Market Database	Mon 6/2/08	Fri 1/30/09
105	4.2.1	O/D Data	Mon 6/2/08	Tue 9/30/08
106	4.2.2	Socioeconomic Data	Mon 6/2/08	Tue 9/30/08
107	4.2.3	Network Data	Mon 6/2/08	Tue 9/30/08
108	4.2.4	Stated Preference Survey/Data	Tue 7/1/08	Fri 1/30/09
109	4.3	Engineering Database	Mon 6/2/08	Tue 9/30/08
110	4.3.1	Track Chart Database	Mon 6/2/08	Tue 9/30/08
111	4.3.2	Track Review	Tue 7/1/08	Tue 9/30/08
112	4.3.3	Engineering Cost Database	Fri 8/1/08	Tue 9/30/08



Study Work Schedule: Tasks 4.4 thru 8.4

ID	Task #	Task Name	Start	Finish
		Database		
113	4.4	Technology Database	Mon 6/2/08	Tue 9/30/08
114	4.4.1	Technology Review	Mon 6/2/08	Tue 9/30/08
115	4.4.2	Technology Database	Fri 8/1/08	Tue 9/30/08
116	4.5	Property Database	Mon 6/2/08	Tue 9/30/08
117	4.5.1	Develop Station Plan	Mon 6/2/08	Tue 9/30/08
118	4.5.2	Develop Station Database	Fri 8/1/08	Tue 9/30/08
119	4.6	Existing Conditions Report	Mon 9/29/08	Tue 10/14/08
120	**5.0**	**Preliminary Service Scenarios**	**Tue 7/1/08**	**Fri 11/28/08**
121	5.1	Review Alternative Routes/Technology	Tue 7/1/08	Fri 10/31/08
122	5.2	Develop Service Concepts	Tue 7/1/08	Fri 10/31/08
123	5.3	Alternatives Development Workshop Preparation	Fri 8/1/08	Tue 10/14/08
124	5.3.1	Alternatives Development Workshop	Thu 10/30/08	Thu 10/30/08
125	5.4	Alternatives Development Technical Report	Fri 11/14/08	Fri 11/28/08
126	**6**	**Alternatives Analysis**	**Mon 9/1/08**	**Fri 2/6/09**
127	6.1	Calibrate COMPASS™ Demand Model	Mon 9/1/08	Fri 11/28/08
128	6.2	Prepare Ridership and Revenue Forecasts	Mon 11/3/08	Fri 1/30/09
129	6.3	Interactive Analysis	Mon 9/1/08	Fri 1/30/09
130	6.4	Develop Operating and Capital Costs	Fri 10/31/08	Fri 1/30/09
131	6.5	Ridership and Revenue Report	Wed 1/21/09	Fri 2/6/09
132	6.6	Alternatives Technical Report	Wed 1/21/09	Fri 2/6/09
133	**7**	**Feasibility Determination**	**Fri 10/31/08**	**Tue 3/17/09**
134	7.1	Financial Analysis	Mon 11/3/08	Tue 3/3/09
135	7.2	Economic Analysis - Users	Mon 11/3/08	Tue 3/3/09
136	7.3	Economic Analysis - Communities	Thu 1/1/09	Tue 3/3/09
137	7.4	Financing and Funding Arrangements	Thu 1/1/09	Tue 3/3/09
138	7.5	Institutional Framework	Fri 10/31/08	Tue 3/3/09
139	7.6	Allocation of Costs and Revenues	Thu 1/1/09	Tue 3/3/09
140	7.7	Final Recommendation	Mon 2/2/09	Tue 3/3/09
141	7.7.1	Recommendation Memorandum	Tue 3/3/09	Tue 3/17/09
142	**8**	**Task Documentation**	**Mon 2/2/09**	**Mon 6/15/09**
143	8.1	Implementation Plan	Mon 2/2/09	Thu 4/30/09
144	8.2	Business Plan	Mon 3/2/09	Fri 5/29/09
145	8.3	Draft Report	Thu 5/14/09	Thu 5/14/09
146	8.4	Final Report	Mon 6/15/09	Mon 6/15/09



Public Involvement Highlights

- **Three corridor input team scoping meetings held**
  - Denver (9/10)
  - I-70 (9/11)
  - I-25 (9/16)
- **Scoping report in progress**
- **Community partnership program initiated**
- **Web site updates**

Corridor Input Team Scoping Meetings

- **Invitations broadly distributed via MPOs, TPRs and I-70 coalition**
- **Meetings summarized the study and gathered high-level input related to:**
  - Vehicle technology categories
  - Alignments
  - Local activity centers (existing/planned)
  - Local future vision
  - Local concerns/issues
- **Verbal comments gathered at meeting; Written comments still coming in**

Scoping Meeting Attendees

- Arvada
- Avon
- Breckenridge
- CDOT
- Central city
- Clear creek county
- Colorado springs
- Copper mountain
- Denver
- Dillon
- DRCOG
- Eagle county
- El Paso county
- Empire
- Evans
- Fort Carson
- Fort Collins
- Frederick
- Frisco
- Golden
- Grand county
- Grand junction
- Georgetown
- Jefferson county
- Lakewood
- Larkspur
- Lone tree
- Mesa county
- Mountain metro transit
- NFRMPO
- NWTPR
- PPACG
- Routt county
- SCCOG
- Silverthorne
- Silver Plume
- Steamboat Springs
- Summit County
- Summit Stage
- Timnath
- Trinidad
- Wheat Ridge
- Yampa

Individual consultation w/ RTD, DIA and other entities

Key Technology Considerations

- **Physical/Performance**
  - Maximum grade, speed and tilt capabilities
  - Acceleration and braking
  - Operational reliability and in-service history
- **General**
  - Weight, size, seating capacity
  - Light freight and baggage capabilities
  - Emergency evacuation safety procedures
- **Economic**
  - Staffing (train crew size & duties, station staff size & roles)
  - Operating, maintenance and capital costs
  - Regulatory approvals

Vehicle Technology Categories

Type	Power Source	Maximum Operating Speeds*
Conventional Rail	Electric or Diesel	79 mph
High-Speed Rail	Electric or Diesel	110 – 130 mph
Very High-Speed Rail	Electric	150 – 220 mph
Ultra High-Speed	Electric	250 – 300 mph

** Actual operating speeds would vary depending on community sensitivities, topography and other factors. Particularly in densely populated and other sensitive areas, actual operating speeds would be much lower than these speeds.*

Scoping Input Thus Far

Technology

- **General support for the categories of technologies to be evaluated**
- **User/system interoperability is of greater importance than technology interoperability**
  - Benefits of technology interoperability were identified
- **“Proven technology” was an important evaluation criteria**
- **Support for evaluating conventional rail technologies**

Key Alignment Considerations

- **I-70 Corridor**
  - Grades and curves (speed vs. cost)
  - Do not assume I-70 reconstruction
  - Environmental sensitivities
  - Local plans/needs/desires
- **I-25 Corridor**
  - Constraints on existing rail alignment (pending Rail Relocation Study)
  - New "greenway" alignment not dependent on freight rail relocation but very costly
  - Local plans/needs/desires
- **Denver Metro Area**
  - Connection and coordination with DIA and FasTracks
  - Local plans/needs/desires
  - Distinction between local and intercity service

General Alignment Options

Scoping Input Thus Far

Alignments / Stations

- General understanding and agreement of general corridors and secondary corridors to be evaluated
- Explicit desire to not limit alignment options to highway routes
- Some concern with conflict between intercity station spacing and desires for more local access/service
- Desire for a transparent station-selection process (I-25 corridor)
- Concern over ROW sharing among the options between possible future commuter rail and high-speed rail alignments (N. I-25 corridor)

Scoping Input Thus Far

Study Comments / Questions

- Strong support for the market-driven approach, particularly related to stations
- Interest in coordination between our stated preference survey and front range MPOs' "front range survey"
- Desire to see greater participation from more key entities in northern Colorado

Scoping Input: *Next Steps*

- **Compile and review all input from comment forms (responses still coming in)**
- **Develop and submit Scoping Report to RMRA**
  - Scoping process overview
  - Summary of scoping input
- **Use report to help inform Alternatives Workshop**

Community Partnership Program

- **Study team list has been enhanced by some RMRA members**
  - Not to late to submit recommendations
- **Materials developed and pending approval:**
  - Introduction letter
  - Stock newsletter/web article
  - Study fact sheet
  - Study map

A Look Ahead…

October

- **Finalize Scoping Report**
- **Outreach to Community Partnership Program**
- **Schedule and announce Corridor Input Team Alternatives Development meetings (1st week of December)**

November

- **Review/revise project materials based on 10/30 Alternatives Development Workshop**
- **Media outreach surrounding alternatives development**

December

- **Corridor Input Meetings (Alternatives Development)**
- **Outreach to Community Partnership Program**

Technology Existing Conditions

Representative Equipment Options

Conventional 79 mph

Conventional Amtrak

High Speed 110-130 mph

Talgo T21

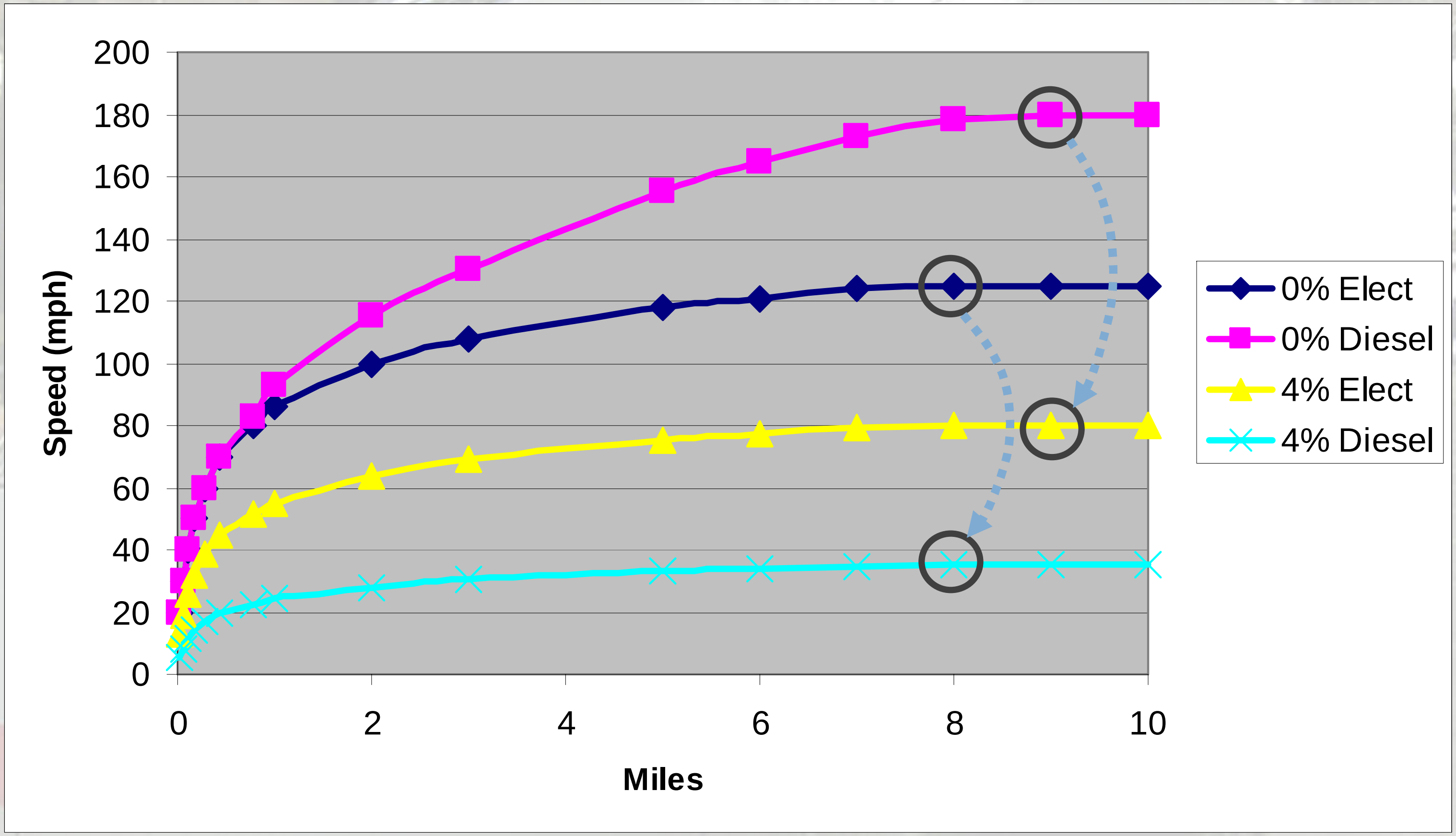
Very High Speed 150-220 mph

Siemens ICE

Ultra High Speed 250-300 mph

Transrapid Maglev

Incremental Rail: Hill Climbing Capability*



* On Straight-and-Level Track versus 4% Uphill Grade

This shows the clear superiority of electric technology for severe gradient applications

FRA Equipment Regulations

- **Basic safety rules for window glazing, interior lighting, baggage handling, etc.**
  – Applies to all equipment types including maglev.

- **Tier I and tier II crashworthiness standards.**
  – For equipment that is operated on the US national rail system.
  – Buff strength requirement for passenger cars of 800,000# is the **same** for both tier I and tier II passenger cars.
  – Tier II locomotives need 2,100,000# buff strength.
  – Tier II equipment must be designed for “crash energy management.”
  – Leading unit may not be occupied by passengers in tier II equipment.

Locomotive Hauled Vs Self Propelled

- **Locomotive-Hauled**

1st Generation ICE Train: Loco-Hauled

- The locomotive provides a buffer to the passenger compartment in case of a collision – In the US, passenger seating is prohibited in the leading unit of a Tier II passenger train.

- **Self-Propelled**

3rd Generation ICE Train: EMU

- Every axle can be powered for more total power, but only 50% were needed in Germany
- Greater operating efficiency and flexibility
- FRA Regulations prohibit occupied 1st Car above 125-mph

Rail Adhesion Factors

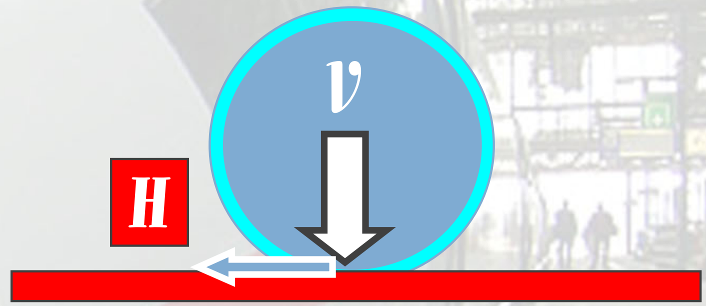
1st Generation ICE Train: Loco-Hauled

- Weight of two locomotives: 187 tons
- Total train 2,174,000 pounds for 645 seats
- Assume μ = 15% *(A safe assumption for wet rails)*
- Tractive Effort Capability =
  187 x 2000 x 15% = 56,100 pounds
- **Maximum Grade = 56,100 / 2,174,000 = 2.6%**

3rd Generation ICE Train: EMU

- Train Weight: 1,000,000 pounds for 404 seats
- 50% of axles powered
- Assume μ = 15%
- Tractive Effort Capability =
  500 x 2000 x 50% x 15% = 75,000 pounds
  (could be 150,000 pounds if all axles were powered)
- **Maximum Grade = 75,000 / 1,000,000 = 7.5%**
  (**<u>could make 15%</u>** if all axles were powered)

$$H = \mu V$$



μ = Coefficient of Adhesion

V = Vertical Component, Vehicle Weight

H = Horizontal Component, Tractive Effort

Representative Rail Equipment

- **American Trains**
  - **Diesel Power**
    - Coaches powered by Boise Locomotive rebuilt diesel
    - Coaches powered by General Electric P-40
    - Colorado Railcar DMU
  - **Electric Power**
    - Acela High Speed Train
    - Conventional Train powered by HHP-4 Electric Locomotive

- **European and Japanese Trains**
  - **Diesel Power**
    - British HST 125
    - German VT605 (ICE-TD DMU)
    - Spanish Talgo Diesel
  - **Electric Power**
    - Italian Pendolino
    - British ICE-225
    - French TGV Duplex
    - German ICE-3
    - Spanish Talgo Electric
    - Swedish X2000
    - Shinkansen N700

Maglev Review

- **LSM Motor (Guideway Based)**

German Transrapid

- Speeds of up to 300-mph proven in daily operation
- In operation at test track and Shanghai airport line
- Very expensive guideway
- It will be difficult to achieve the geometric standards required by this guideway on the I-70 corridor. It may be achievable on I-25.

- **LIM Motor (Vehicle Based)**

Japanese HSST

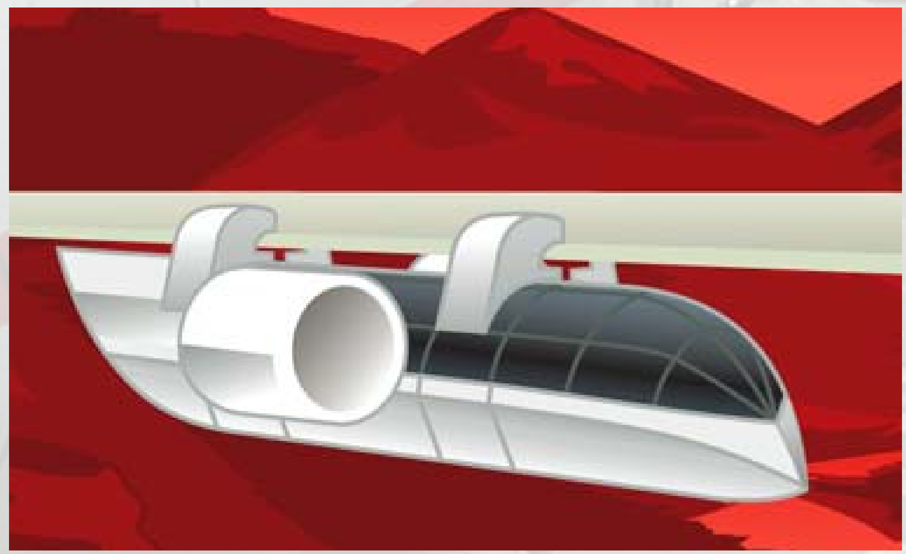
- This type of system was suggested by the 2004 Colorado Maglev study
- Speeds of up to 60-mph proven in daily operation – but speeds of 100-mph are unproven and require system enhancement
- LIM guideway more economical than LSM
- In operation at test track and Nagoya's Tobu Kyuryo line
- American Maglev has similar technology but no revenue implementation experience

Novel Technologies

Labis Train

Data Collection is Under Way . . . .

Air Train Global



Fall Survey Status

Survey Goal

- Quantify how much travelers value time and frequency
- Discriminate behavior by mode and purpose of travel
- Evaluate O/D flows

This will be achieved using a <u>quota</u> survey.

Proposed Survey Locations

Location	Fall	Winter
Denver Int'l Airport	✖	✖
Denver Bus Stations (RTD/FREX/Greyhound)	✖	
Resorts*		✖
Ski Train/Amtrak	✖	✖
DMV	✖	

*** Resorts dropped from the Fall Survey due to low activity at this time.**

Survey Schedule and Targets

Fall Survey Team Planned Deployment

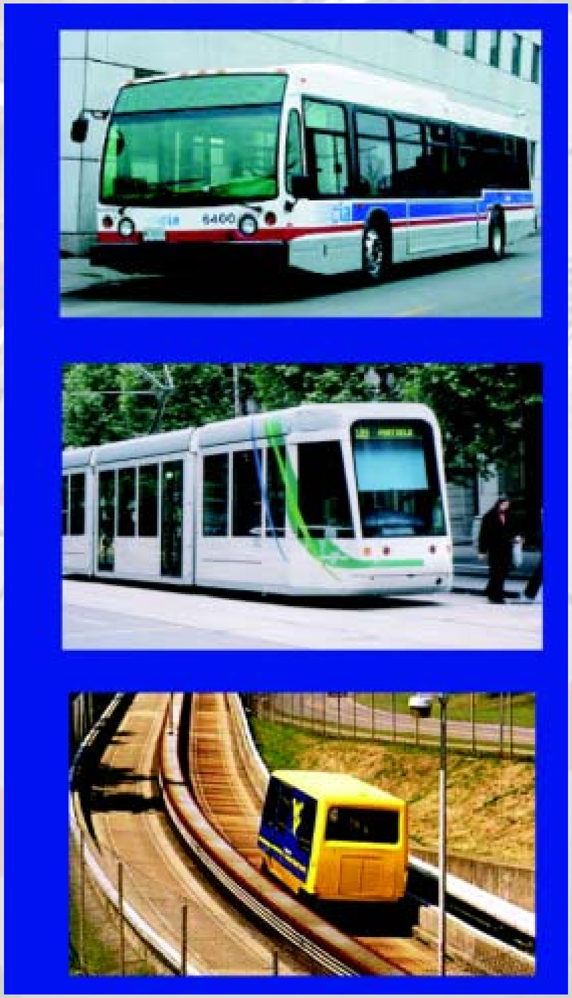
	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
	2-Oct	3-Oct	4-Oct	5-Oct	6-Oct	7-Oct	8-Oct	9-Oct	10-Oct	11-Oct	12-Oct
DIA Airport Survey											
Colorado Springs DMV and FREX Bus											
Glenwood Springs DMV and Amtrak											
Denver DMV, Amtrak and RTD Bus											
Denver Amtrak and RTD Bus											

Fall Survey Team Targets

Location	Survey Goal
DIA Airport	1,000
Amtrak	200
RTD Regional Bus	250
FREX Bus	100
DMV	1,000
TOTAL	**2,550**

Station Spacing Guidelines

Station Spacing Guidelines



Local Bus

- Service Area: Urban and suburban uses, ½ to 5 miles
- Typical Speeds: 10 mph
- Station Spacing: 2 to 4 blocks

Streetcar

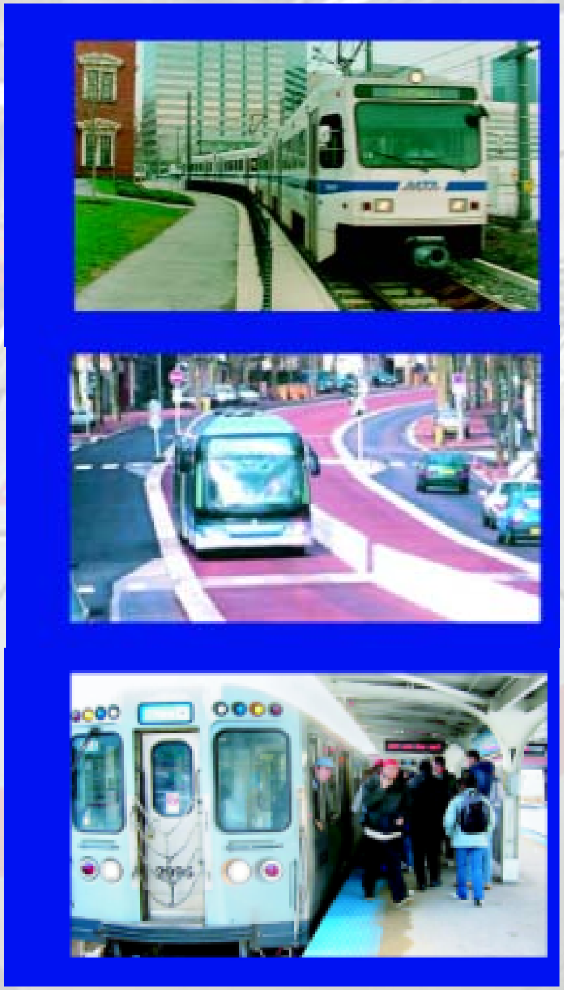
- Service Area: Urban and suburban streets, ½ to 6 miles
- Typical Speeds: 10 mph
- Station Spacing: 2 to 4 blocks

Personal Rapid Transit

- Service Area: Small area networks or campuses, 1 to 5 miles
- Typical Speeds: 15 mph
- Station Spacing: ¼ to 1 mile

Source: DMJM + Harris/CTE Engineers

Station Spacing Guidelines



Light Rail

- Service Area: Urban or suburban uses, 1 to 10 miles or more
- Typical Speeds: 15 to 25 mph
- Station Spacing: ¼ to 1 mile

Bus Rapid Transit

- Service Area: Urban and suburban uses, 1 to 10 miles or more
- Typical Speeds: 15 to 25 mph
- Station Spacing: ¼ to 1 mile

Heavy Rail

- Service Area: Urban uses and loadings, 1 to 10 miles or more
- Typical Speeds: 25 to 40 mph
- Station Spacing: ¼ mile downtown, up to 2 miles in neighborhoods

Source: DMJM + Harris/CTE Engineers

Station Spacing Guidelines

Automated Guideway/Monorail

- Service Area: airports, theme parks, circulators, ½ to 5 miles
- Typical Speeds: 15 to 30 mph
- Station Spacing: 1/2 to 2 miles

Commuter Bus

- Service Area: Suburbs to city, 15 to 100 miles
- Typical Speeds: 30 to 50 mph
- Station Spacing: 3 to 7 miles, or at end points

Commuter Rail

- Service Area: Suburbs to city, 15 to 100 miles
- Typical Speeds: 30 to 50 mph
- Station Spacing: 3 to 7 miles

Source: DMJM + Harris/CTE Engineers

Station Spacing Guidelines

High Speed Rail

- Service Area: Intercity, 150 to 300 miles
- Typical Speeds: 110 to 186 mph
- Station Spacing: 20 to 50 miles

Maglev

- Service Area: Intercity, 100 to 300 miles
- Typical Speeds: 250 to 340 mph
- Station Spacing: 20 to 50 miles

Source: DMJM + Harris/CTE Engineers

Increased Speed Means Greater Station Spacing

Local Bus (10mph)

2-4 blocks

Commuter Rail (30-50mph)

3-7 miles

Intermediate Rail (90-120mph)

10-30 miles

High Speed Rail (120-200mph)

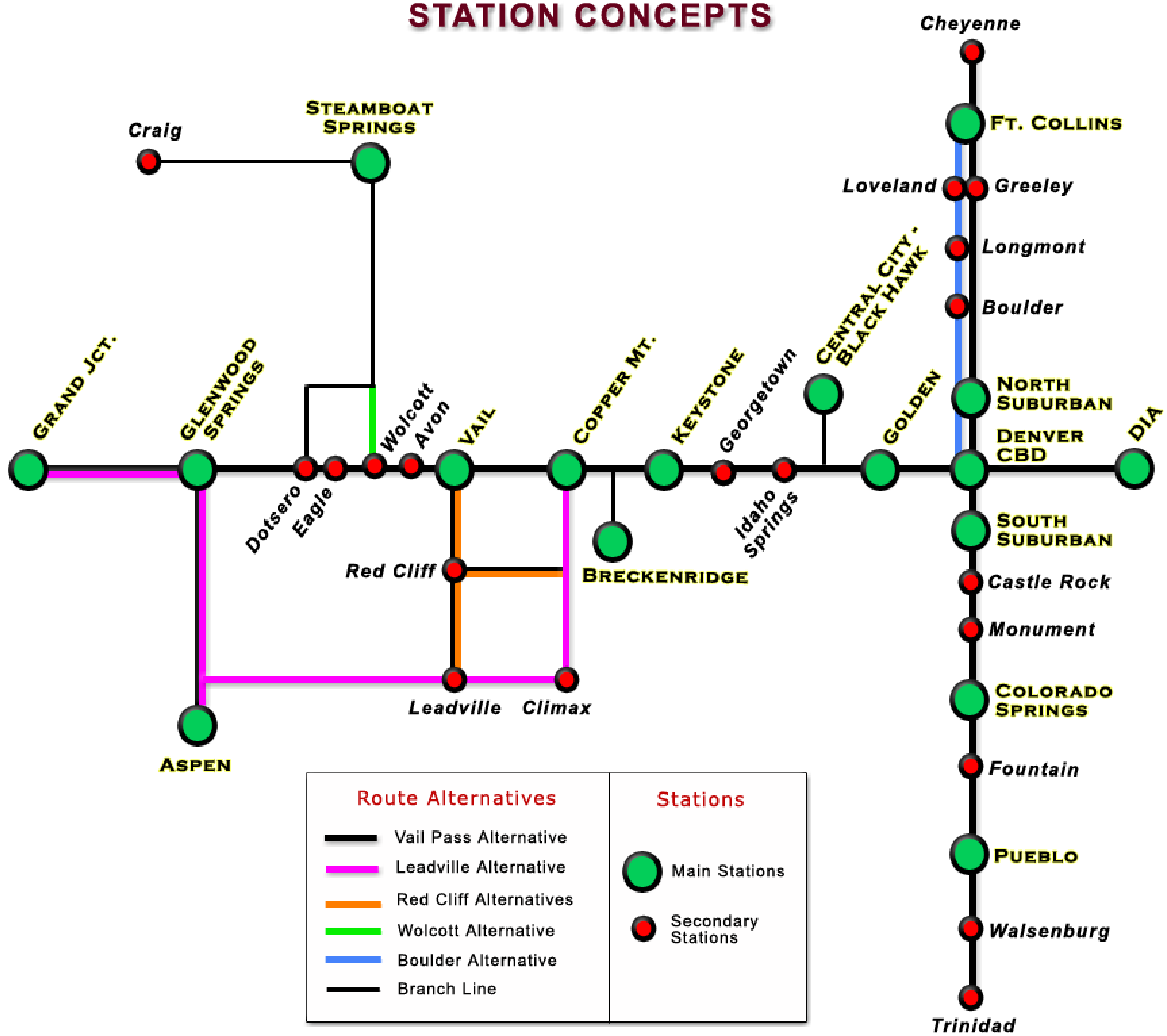
20-50 miles

Maglev (250mph)

20-100 miles

← RMRA Study Range →

STATION CONCEPTS



Demand Validation Process

Demand Model Validation

1. **Total Demand – Compare with historic trends by mode.**
2. **Elasticity Analysis – Comparison with known elasticities (e.g., other corridors that have been developed or are in development).**
3. **Benchmark Analysis – Comparison with total demand, induced demand, and modal split for other corridors. (e.g., Boston-Portland, Northeast Corridor).**

Thank You.